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No. 531

TANK TESTS OF MODEL 11-G FLYING-BOAT HULL

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SUMMARY

The N.A.C.A. model 11-G flying-boat hull, a modification of N.A.C.A. model 11-A, was tested in the N.A.C.A. tank over a wide range of loadings. The planing bottom of model 11-G has a variable-radius flare, or concavity, at the chines in contrast to the straight V planing bottom of model 11-A. The results are given as curves of resistance and trimming moment plotted against speed for various angles of trim. The characteristics of the form at the optimum angles of trim are given in nondimensional form as curves of resistance coefficient, best trim angle, and trimming-moment coefficient plotted against speed coefficient.

As compared with the original form, model 11-G is shown to have higher resistance at all loads and speeds and higher maximum trimming moments at heavy loads. The spray pattern, however, is generally more favorable, indicating that the service performance of model 11-A would be improved by some form of chine flare.

INTRODUCTION

The N.A.C.A. model 11-A flying-boat hull is a type similar to that found in several U. S. Navy patrol and bombing seaplanes. Tank tests of this model (reference 1) have shown that a longitudinally straight planing bottom having straight V sections combined with a short pointed afterbody gives desirable smooth-water resistance and trimming-moment characteristics.

It was suggested by Captain H. C. Richardson, U.S.N., Retired, that the service performance of model 11-A would be improved by modifying the sections of the planing bottom to include a horizontal chine flare. A forebody embodying this suggestion was designed and built and was combined with the original model 11-A afterbody to form N.A.C.A. model 11-G. The combination was tested in the N.A.C.A. tank in August 1934.

DESCRIPTION OF MODEL

The lines of model 11-G are shown in figure 1. The keel and chine lines are identical with those of model 11-A; the sections from station 1-1/2 to station 10 are modified as shown in the detail of figure 1. The straight portion of each section in this region is determined from the "false chine" faired approximately as suggested by Captain Richardson and gives a small change in angle of dead rise over the planing bottom. The radius and tangency of the flare at each station follow from the condition that the flare is horizontal at the real chine. The radius of the flare therefore increases from zero at station 1-1/2 to a maximum value at station 5 and decreases again to zero at the step. The sections forward of the flared region are made slightly fuller than those of 11-A to maintain fair buttocks and water lines throughout.

Faired offsets of the resulting form are given in table I. These offsets were followed closely in the shaping of the model used for the tests. Following the usual practice at the N.A.C.A. tank, this model was constructed of mahogany and smoothly finished with gray-pigmented varnish.

APPARATUS AND PROCEDURE

The N.A.C.A. tank and its methods of operation are described in reference 2. The model suspension used in testing model 11-G is shown in reference 3. The device to obtain trimming moments consists of a stiff calibrated spring, one end of which is attached rigidly to the suspension frame and the other to the model. Trimming moments acting on the model cause it to rotate slightly within the allowable deviation of trim angle ($\pm 0.1^\circ$). The deflection of the spring is read on a dial gage and the moment determined from a calibration curve.

The model was tested by the "general" method described in reference 2 in which resistance, trimming moment, and draft are recorded for predetermined loads and trim angles at a succession of constant speeds. The range of loadings investigated was the same as that used in the tests of model 11-A. The original test schedule was shortened, however, to include only the regions near the hump speed, where resistance and moment reach a maximum, and at planing speeds from speed coefficients of 4.5 to 7.0. Sufficient angles of trim were included to determine the minimum resistance at each speed and load.

RESULTS AND DISCUSSION

Test Data

The resistance and trimming moments obtained from the test of model 11-G are plotted against speed for various trim angles in figures 2 to 7. The resistance plotted is the water resistance plus the air drag of the above-water portion of the model. The trimming moments are referred to the center of moments shown in figure 1, tail-heavy moments being considered positive. The angle of trim τ is the inclination of the model base line to the horizontal.

The curves show the usual trends for this type of hull. A hump appears in the constant-load curves at approximately 16 feet per second, a speed corresponding to the hump, or critical, speed in the take-off. This hump disappears at light loadings. The maximum positive trimming moments occur also near this speed. At high speeds the moments referred to practical center-of-gravity positions are small.

Best Angle Data

When comparing the performance of various hulls by the data from general tank tests, it is desirable to eliminate the variable of trim angle since the value of this angle is measured from a purely arbitrary base line for each hull. This variable is eliminated by determining the resistance and trimming moment at the best angle of trim for a number of loads and speeds throughout the range investigated, from which the optimum performance of the form and the control moments necessary to obtain it are found.

In order to obtain the characteristics of model 11-G at the best trim, the resistance and trimming moment were cross-plotted against trim angle, with load as a parameter, at various selected speeds. At each speed and load, the minimum resistance, best trim angle, and the moment existing were determined from the cross plots and converted to nondimensional coefficients, based on Froude's law of model similitude and using the maximum beam of the hull as the characteristic dimension. The coefficients are defined as follows:

Speed coefficient, $C_V = \dfrac{V}{\sqrt{gb}}$

Resistance coefficient, $C_R = \dfrac{R}{wb^3}$

Load coefficient, $C_\Delta = \dfrac{\Delta}{wb^3}$

Trimming-moment coefficient, $C_M = \dfrac{M}{wb^4}$

where

V is speed, f.p.s.

R, resistance, lb.

Δ, load, lb.

M, trimming-moment, lb.-ft.

b, maximum beam of hull, ft.

g, acceleration of gravity, 32.2 ft. per sec.^{2}

w, specific weight of water, lb. per cu.ft. (63.5 lb. per cu.ft. during the test).

Any consistent units other than those indicated may, of course, be employed.

The resistance coefficient C_R at best trim angle, the best trim angle τ_o, and the trimming-moment coefficient C_M at best trim angle obtained from the cross plots are plotted against speed coefficient C_V, in figures 8, 9, and 10, respectively. These curves give the performance of model 11-G under optimum conditions and, neglecting scale effects, apply to any size of hull.

Comparison with Model 11-A

Check tests of model 11-A in April 1934 using the same gear as that used for testing model 11-G showed a general increase in resistance over that obtained in April 1933 with the gate-type towing gear (reference 1). The change in the model suspension and a possible change in the surface of the model are partial explanations of the differences noted. It is believed, therefore, that the check test affords the better comparison of resistance with the modified form although the qualitative result will be the same in either case. A comparison of the characteristics of the original and the modified form is made by typical cross plots of the best trim-angle data against load coefficient in figures 11 and 12.

Resistance.- Figure 11 shows the comparative values of load-resistance ratio at the hump speed and at various speed coefficients in the planing region. The values for model 11-G are lower than those of model 11-A, the modified sections of the former model having a generally adverse effect on resistance.

Trimming moment.- Figure 12 shows typical C_M values for each form at the best angle of trim. Those given for model 11-A have been referred to the center of moments used for model 11-G. The maximum positive C_M values for model 11-G are greater than those for model 11-A, particularly at heavy loadings; otherwise the differences in moment characteristics are small.

Best angle.- Figure 12 shows the differences in the angle for minimum resistance. The values for model 11-G are approximately 1° lower than those for model 11-A near the hump speed. The differences at higher speed coefficients are negligible.

Spray pattern.- Figures 13 and 14 provide a comparison of the spray thrown from the two forms. At low speeds, the chine flare of model 11-G results in a general reduction in the height and volume of the blisters coming from the forebody, as may be seen from figure 13 and the first four frames of figure 14. The reduction exists for both light and heavy loadings. The last two views of figure 14, however, indicate that model 11-G is dirtier at high speeds, the spray entering the region in which the tail surfaces would probably be located. Near get-away speeds, a hull having constant dead rise and a constant-radius flare near the step should plane cleaner and have a more favorable Δ/R ratio than either model 11-A or model 11-G.

Tests of other hull forms having a chine flare near the step have shown that this feature does not necessarily have the adverse effect on resistance encountered with model 11-G. It is believed, then, that some means of suppressing the large amount of spray inherent in a heavily loaded V bottom with high dead-rise angle would improve the general behavior of model 11-A in service.

CONCLUSIONS

The characteristics of model 11-G at best trim angles compare with those of model 11-A from which it was derived as follows:

1. The resistance was greater throughout the speed range.

2. At heavy loadings, the maximum positive water moment was greater.

3. At the hump speed, the trim angle for minimum resistance was slightly less.

4. At low speeds, the height and volume of spray were lower; at high speeds, the spray in the neighborhood of the tail surfaces was greater.

5. A chine flare that has no adverse effect on resistance would improve the suitability of the 11-A form in service.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 8, 1935.

REFERENCES

1. Parkinson, John B.: A Complete Tank Test of a Model of a Flying-Boat Hull - N.A.C.A. Model No. 11-A. T.N. No. 470, N.A.C.A., 1933.

2. Truscott, Starr: The N.A.C.A. Tank - A High-Speed Towing Basin for Testing Models of Seaplane Floats. T.R. No. 470, N.A.C.A., 1933.

3. Shoemaker, James M.: Tank Tests of Flat and V-Bottom Planing Surfaces. T.N. No. 509, N.A.C.A., 1934.

TABLE I

Offsets for N.A.C.A. Model No. 11-G Flying-Boat Hull (Inches)

Station	Distance from F.P.	Distance from base line							Half-breadths										Radius of chine flare
		Keel	B-1 [1]1.50	B-2 3.00	B-3 4.50	Tangency of chine flare	Main chine	Cove	Upper chine	Tangency of chine	Main chine	Cove	Upper chine	WL-2 [2]11.00	WL-3 9.50	WL-4 8.00	WL-5 6.50		
F.P.	0.00	4.00					4.00				0.25								
1/2	2.40	10.43	6.59				5.28				2.26				0.31	0.86	1.54		
1	4.80	11.80	9.17	7.11			6.33				3.82			0.43	1.30	2.30	3.62		
1-1/2	7.20	12.44	10.63	8.89	7.52		7.20				5.03				2.45	3.91			
2	9.60	12.83		10.09	8.75	8.25	7.93			5.10	5.97				3.64				1.21
3	14.40	13.29				9.62	8.99			5.39	7.23								3.39
4	19.20	13.48				10.29	9.63			5.52	7.94								4.84
5	24.00	13.58				10.57	9.99			5.92	8.28								5.25
6	28.80	13.66				10.59	10.17			6.54	8.44								4.47
7	33.60	13.76				10.50	10.24			7.23	8.50								3.00
8	38.40	13.83				10.46	10.32			7.79									1.70
9	43.20	13.92				10.47	10.40			8.17									.77
10 F.	48.00	14.00					10.48												
10 A.	48.00	13.44					9.92												
11	52.80	12.97					9.45				8.50								
12	57.60	12.51					9.16	8.23	8.10		8.10	8.10	8.40						
13	62.40	12.04					9.16	7.57	7.09		6.97	6.97	8.11						
14	67.20	11.58					9.48	7.21	6.17		5.07	5.07	7.58						
15	72.00	11.11					10.04	7.11	5.38		2.59	2.59	6.77						
S.P.	76.00	10.74 7.34					10.66	7.16			.20	.20							
16	76.80	7.04							4.66				5.78						
17	81.60	5.91							4.00				4.61						
18	86.40	4.77							3.40				3.31						
19	91.20	3.64							2.86				1.90						
20	96.00	2.50							2.33				.40						

[1]Distance from center line (plane of symmetry) to buttock (section of hull surface made by a vertical plane parallel to plane of symmetry).

[2]Distance from base line to water line (section of hull surface made by a horizontal plane parallel to base line).

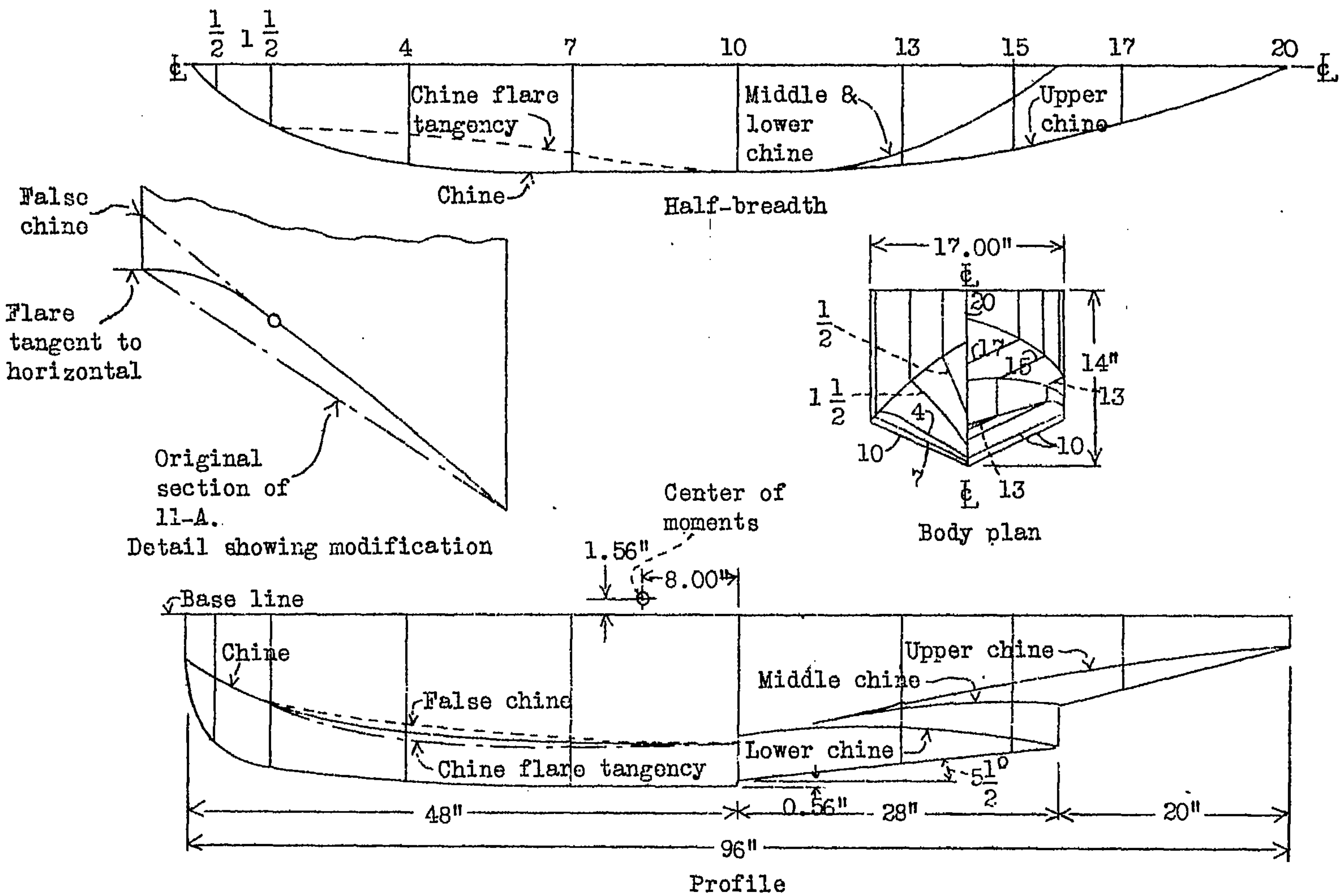


Figure 1.-Lines of N.A.C.A. model 11-G.

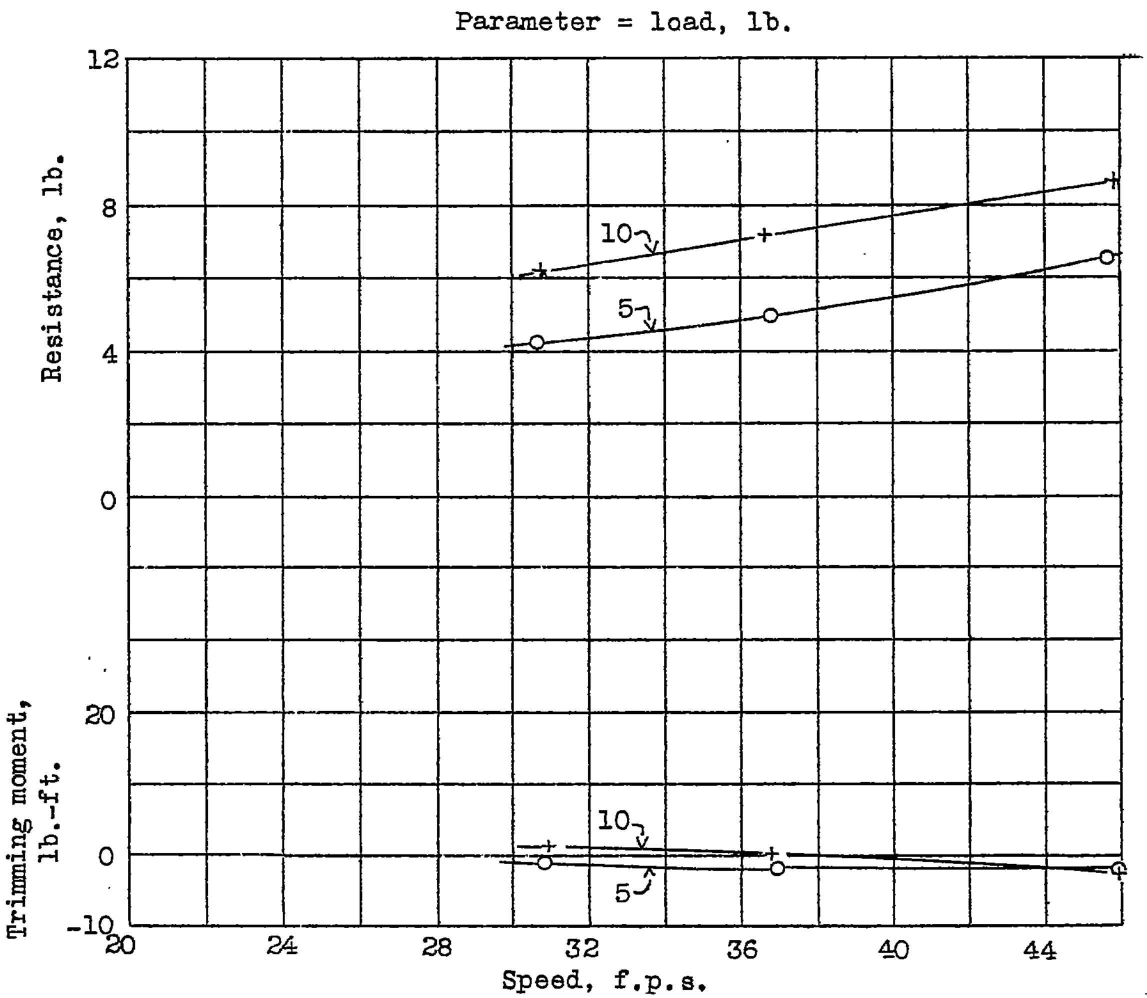


Figure 2.-Resistance and trimming moment. Trim angle, $\tau = 2^{\circ}$.

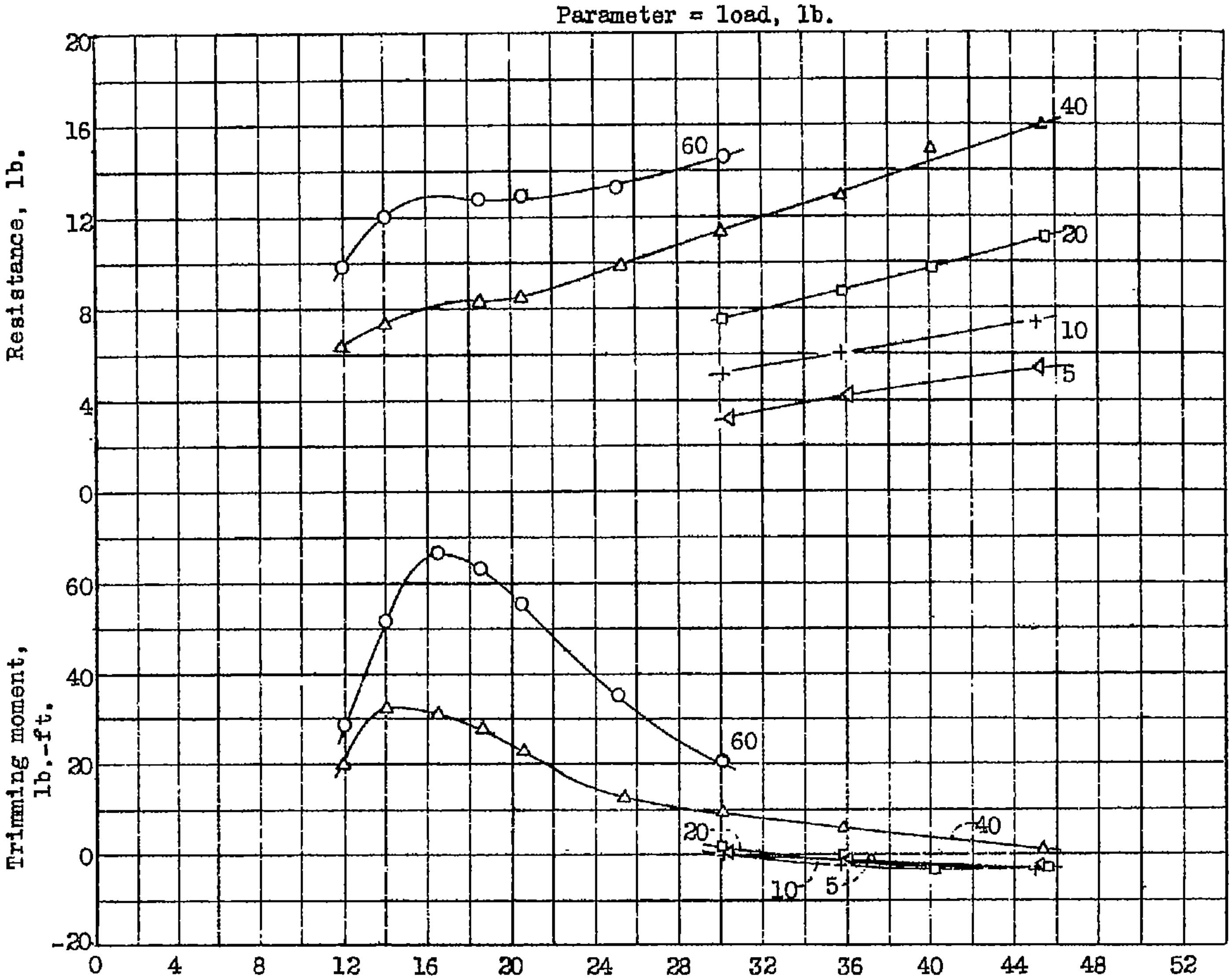


Figure 3.-Resistance and trimming moment. $\tau = 3^{\circ}$.

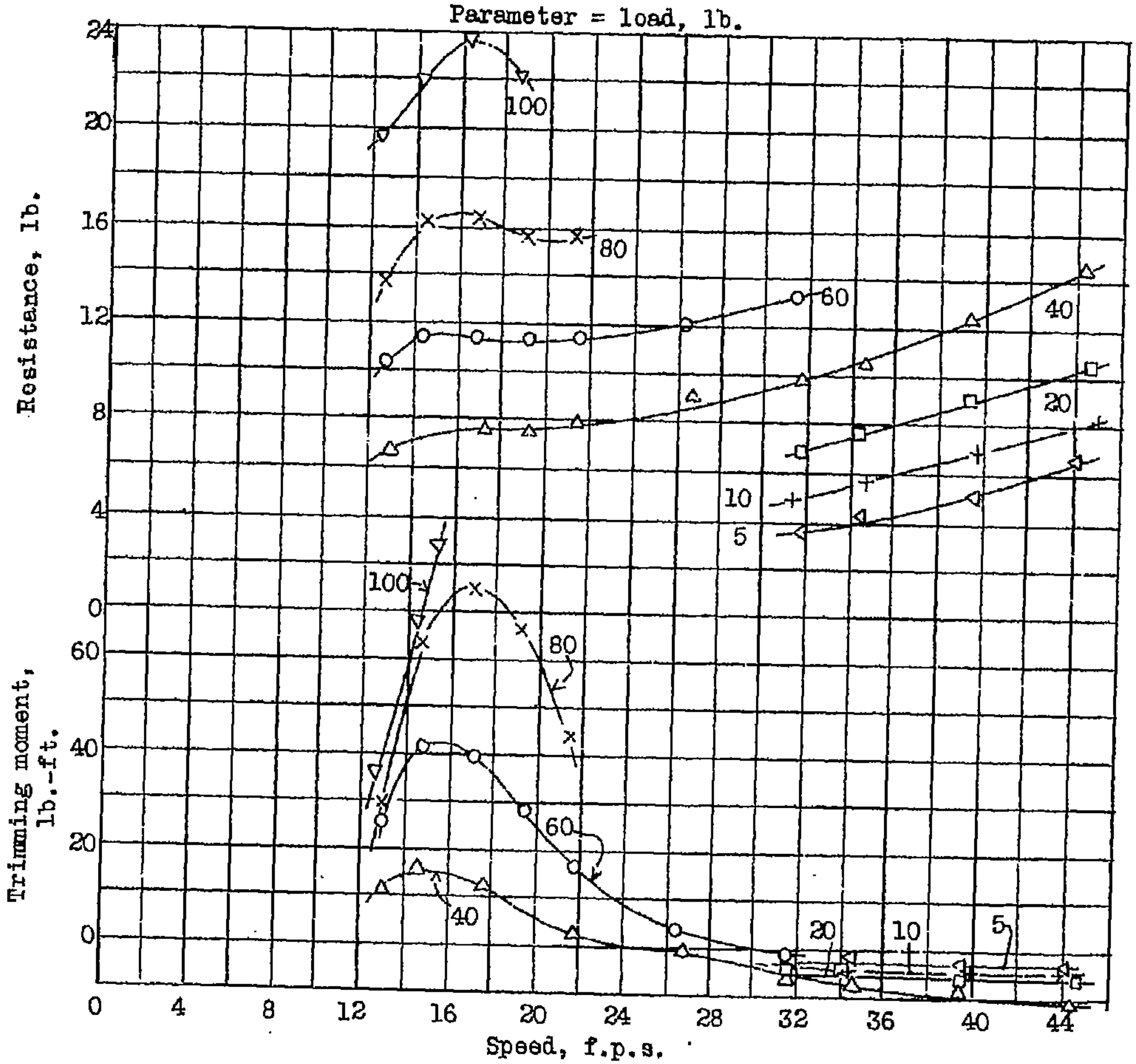


Figure 4.-Resistance and trimming moment. Trim angle, $\tau = 5^{o}$.

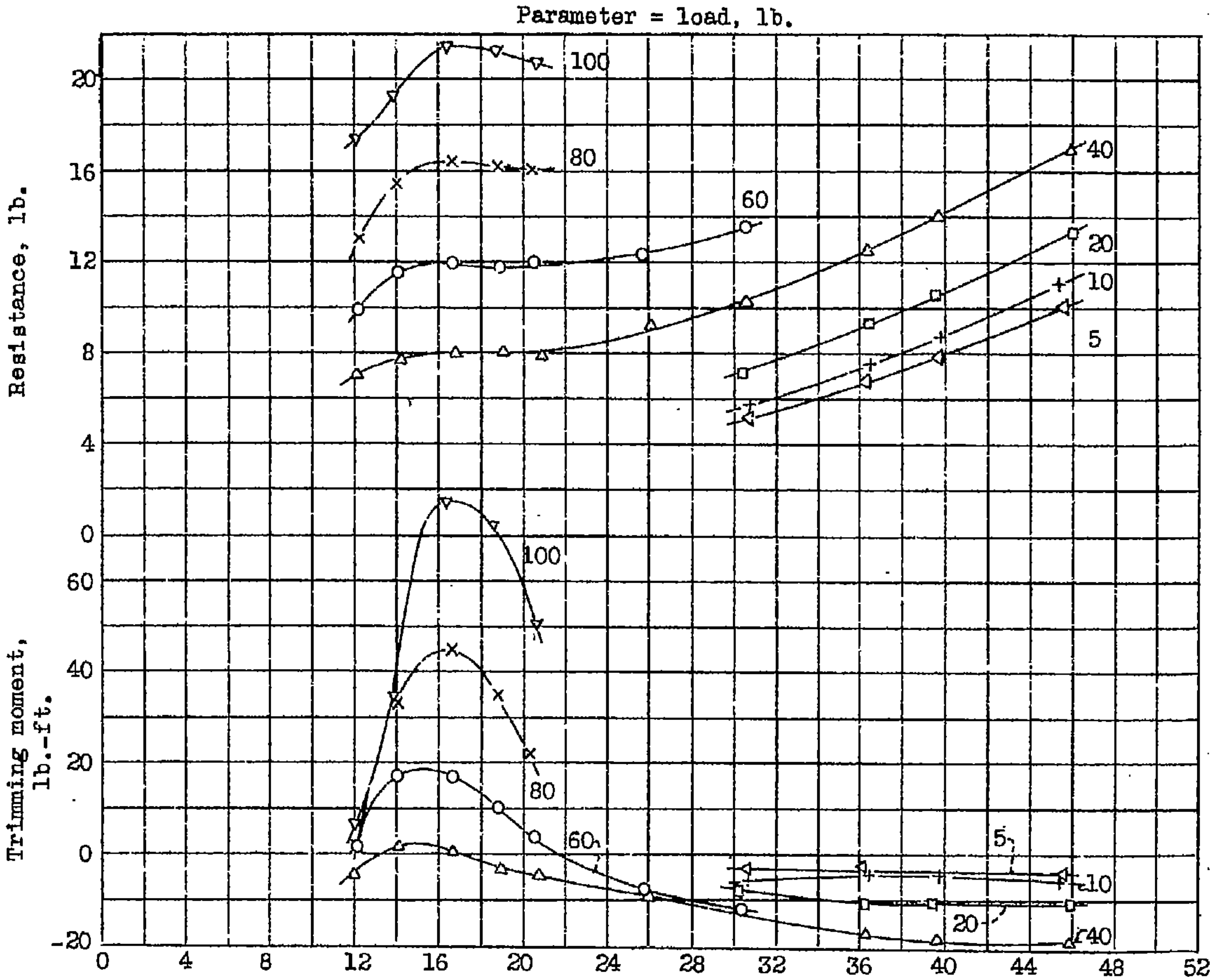


Figure 5.-Resistance and trimming moment. Trim angle, τ = 7°.

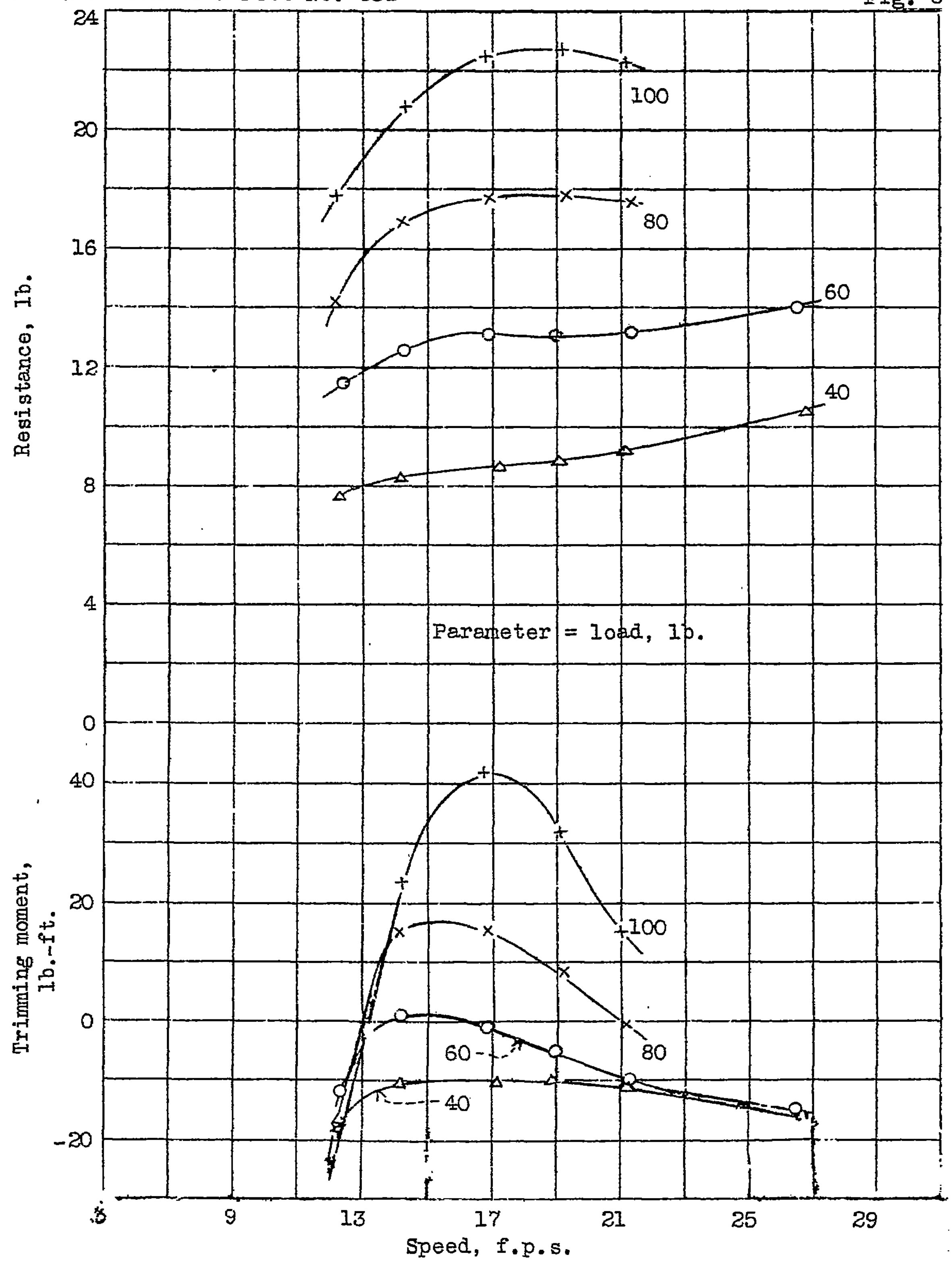


Figure 6.-Resistance and trimming moment. Trim angle, τ = 9°.

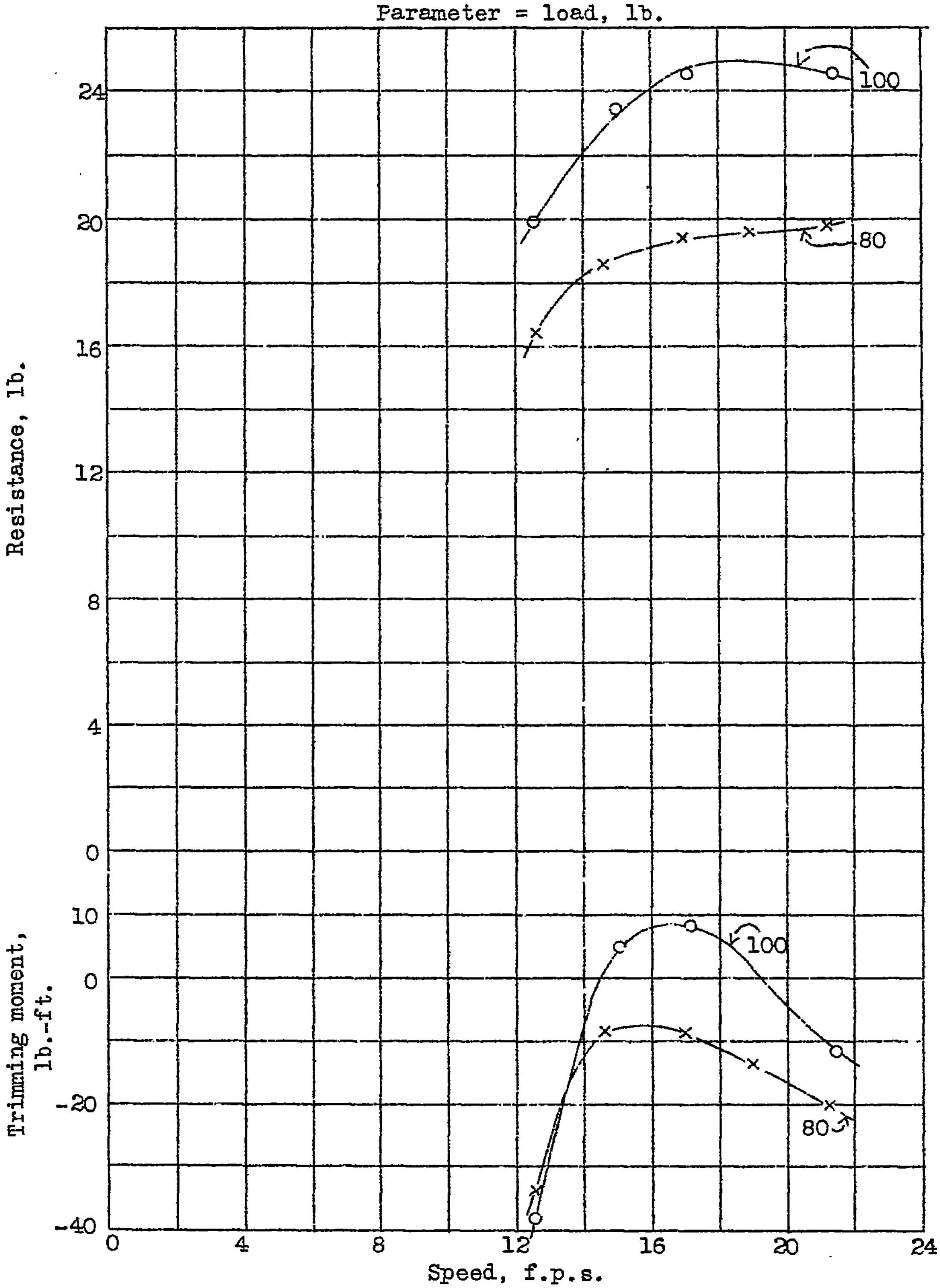


Figure 7.-Resistance and trimming moment. Trim angle, τ=11°.

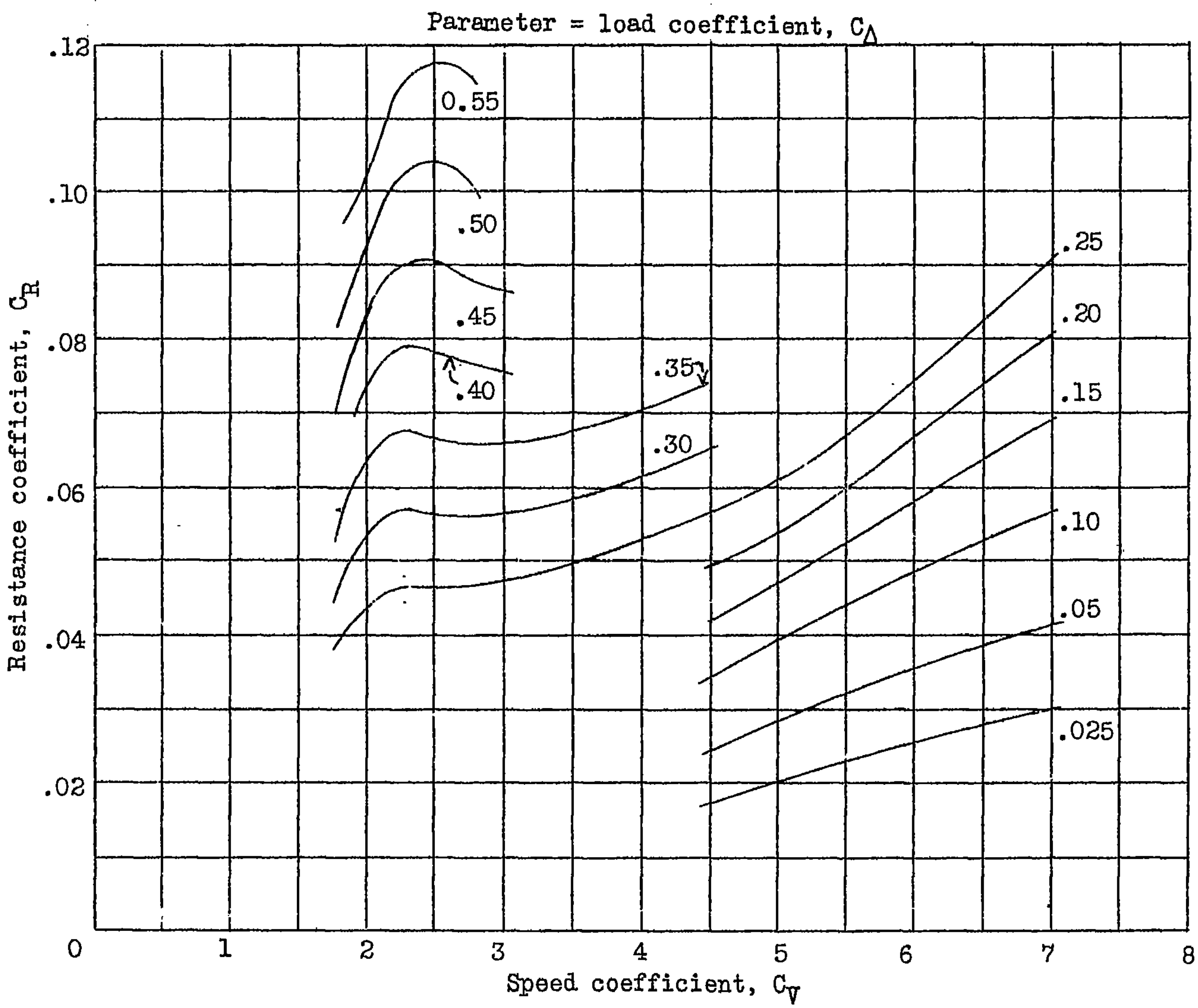


Figure 8.-Resistance coefficient at best trim angle.

Parameter = load coefficient, C_Δ

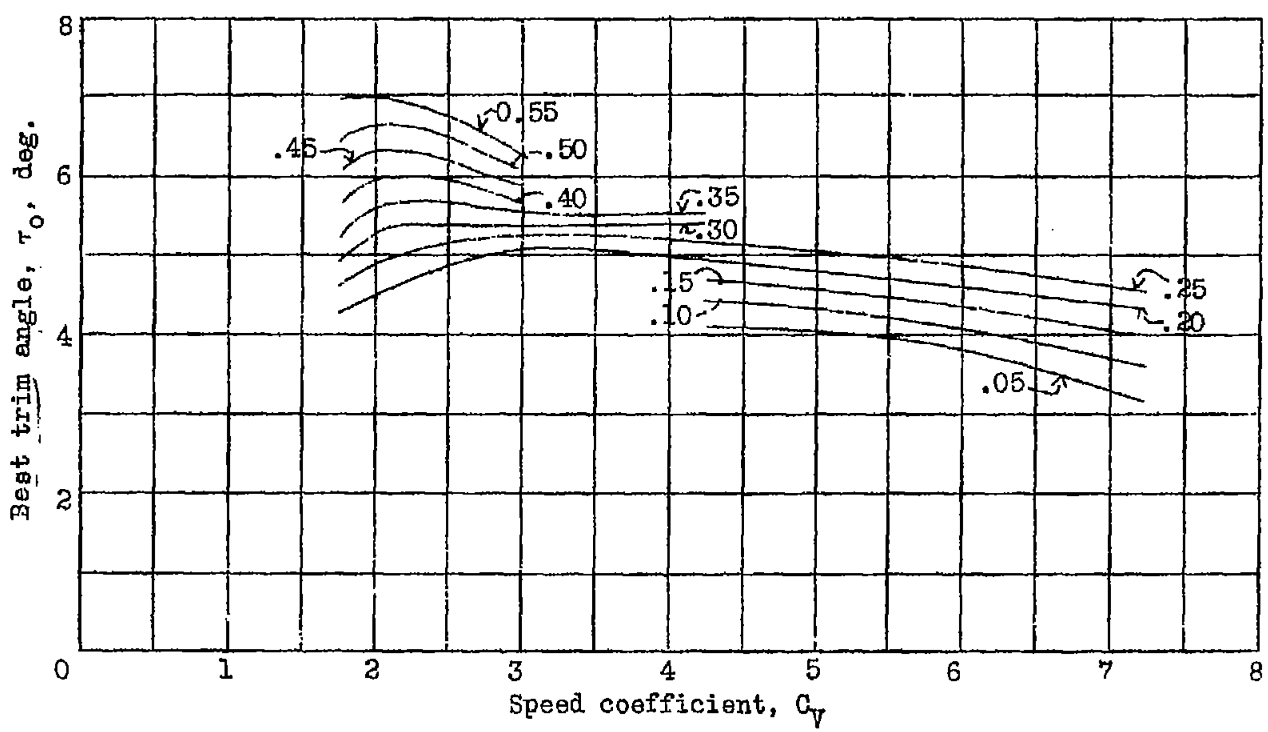


Figure 9.-Trim angle for minimum resistance.

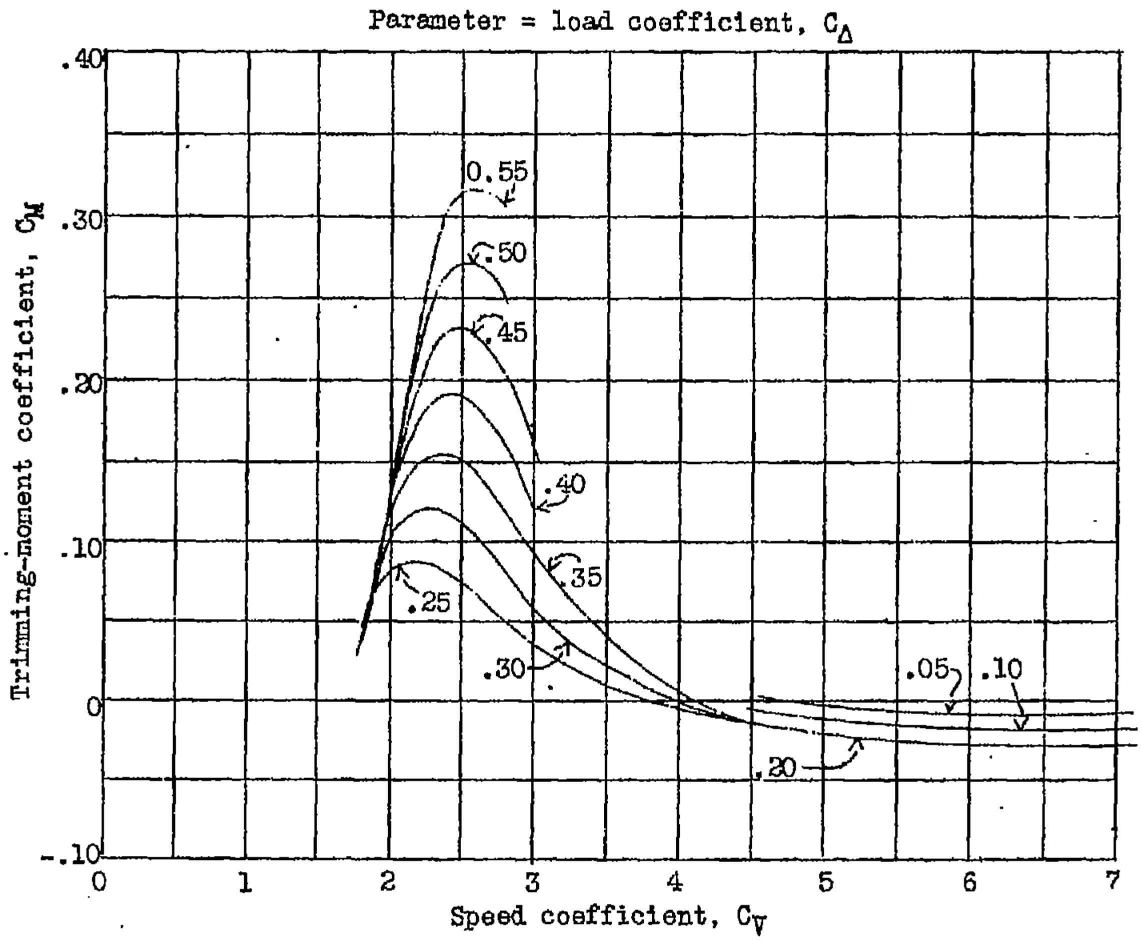


Figure 10.-Trimming-moment coefficient at best trim angle for center of moments 47.06 percent beam forward of step and 91.53 percent beam above keel at step.

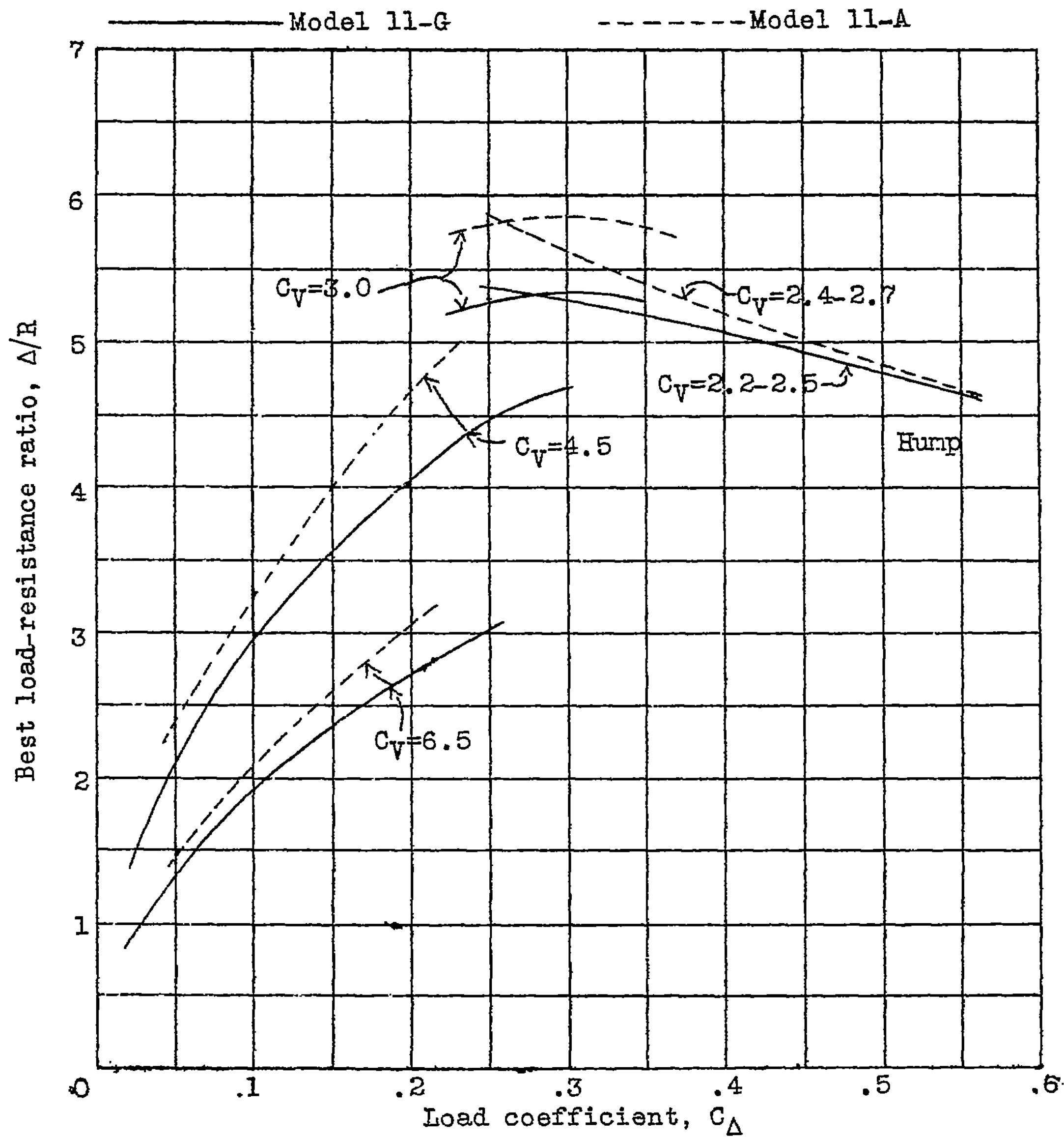


Figure 11.-Effect of modification on load-resistance ratio.

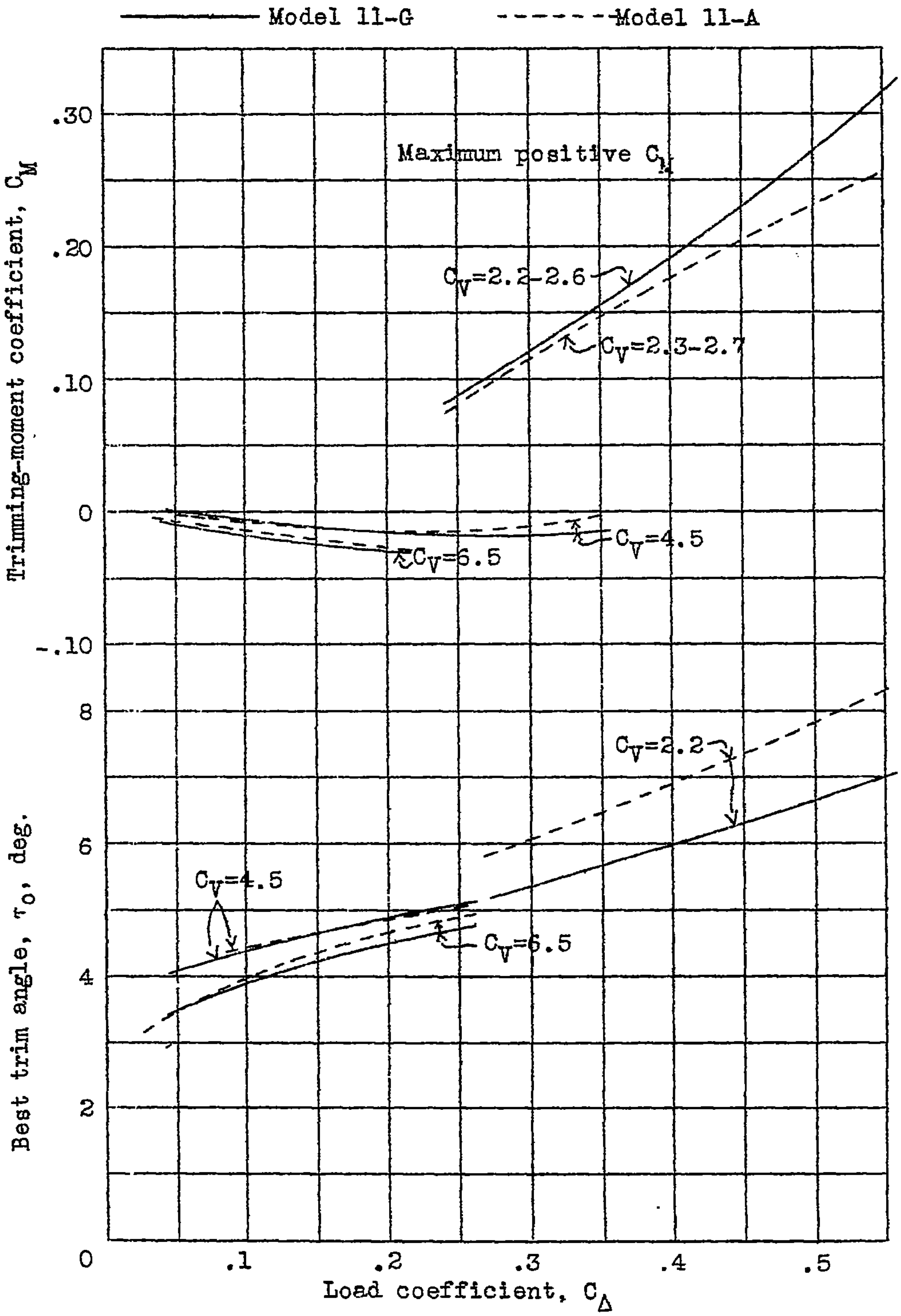
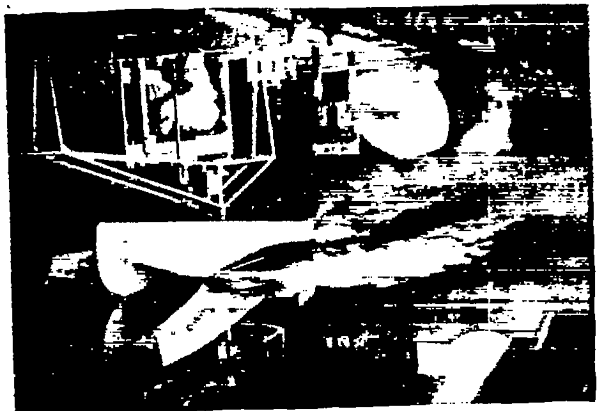


Figure 12.-Effect of modification on trimming-moment coefficient and best trim angle.

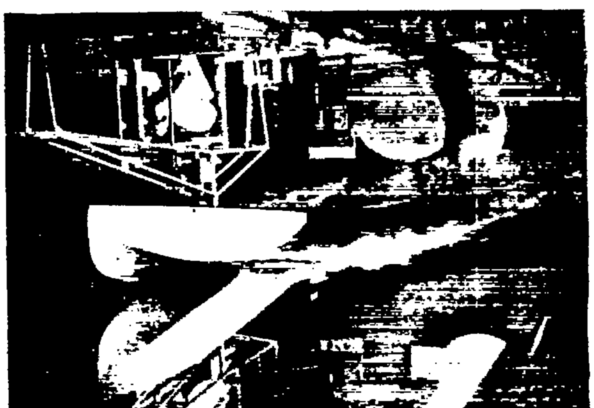
Model 11 G

Model 11 A

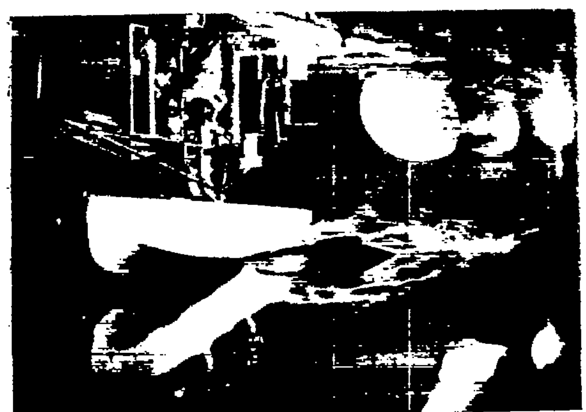


12.0 f.p.s. $\tau = 7^\circ$ $\Delta = 100$ lb.

12.6 f.p.s. $\tau = 7^\circ$ $\Delta = 100$ lb.



14.0 f.p.s. $\tau = 7^\circ$ $\Delta = 40$ lb.



14.6 f.p.s. $\tau = 7^\circ$ $\Delta = 40$ lb.

20.6 f.p.s. $\tau = 7^\circ$ $\Delta = 100$ lb.

20.8 f.p.s. $\tau = 7^\circ$ $\Delta = 100$ lb.

Figure 13.- Effect of modification on spray pattern.

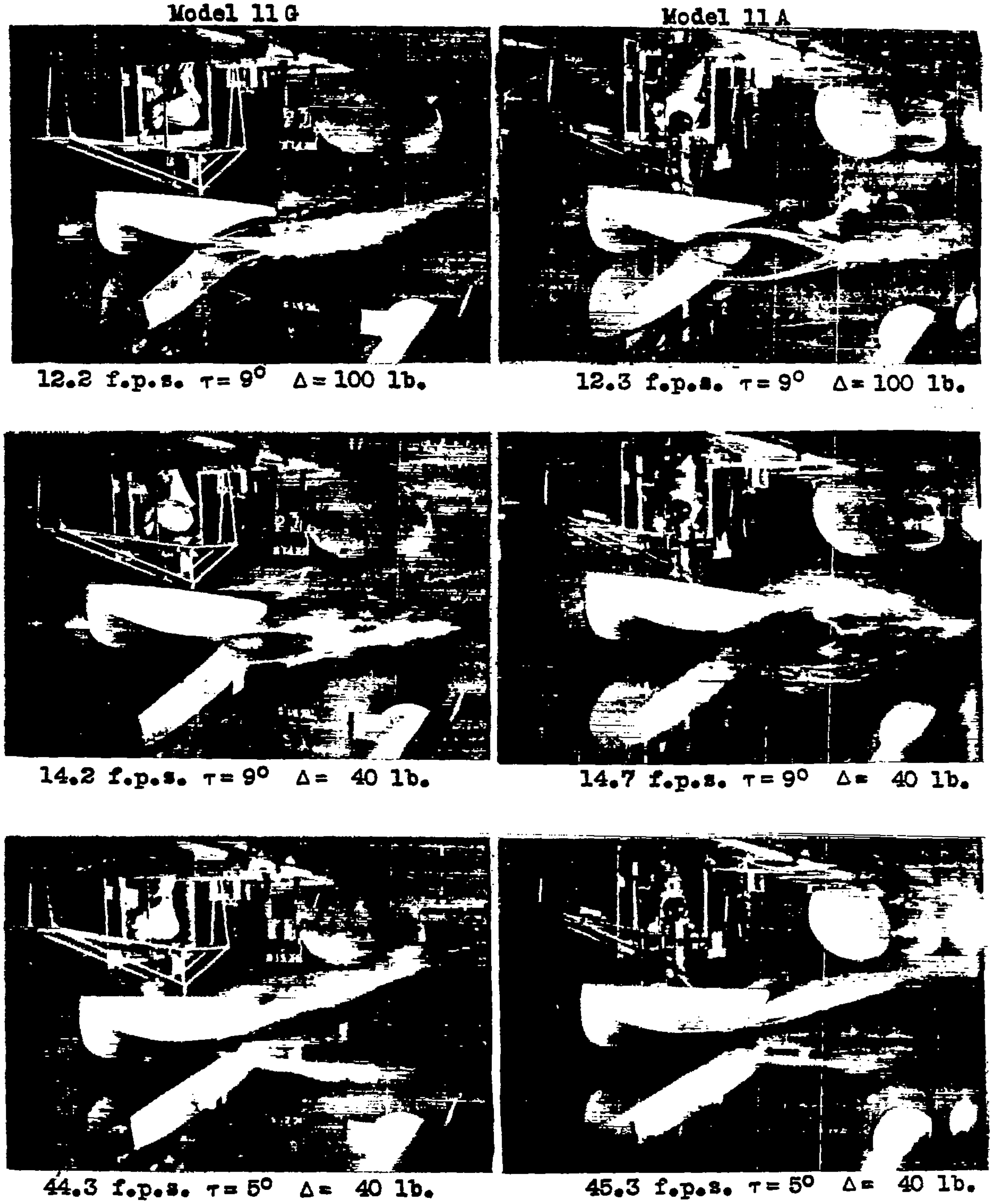


Figure 14.- Effect of modification on spray pattern.